MEASUREMENTS OF THE INTENSITY OF THE NIGHT SKY LIGHT AT CALCUTTA

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ABSTRACT. The paper describes the results of measurements of the night sky intensity variation made at Calcutta on selected nights in 1943-45, taking advantage of the black-out condition of the city. It was found that on undisturbed nights, the night sky intensity decreased with advance of night, attained a minimum near about local midnight and then again increased. This trend of variation is the same as that observed by Karandikar (1934) at Poona and Elvey (1943) at Texas.

Of the total 50 nights observed, 30 per cent were found to be disturbed *i.e.*, the intensity variations were erratic. Not all such nights were associated with magnetic activity. On disturbed nights which were accompanied by magnetic disturbance, the trend of variation was approximately the same as the variation of maximum ionisation of Region-F. (The data for the latter were available from the regular ionospheric observations made at the University College of Science, Calcutta, under the auspices of the Radio Research Committee of the Council of Scientific and Industrial Research.) The significance of this correlation is discussed and it is shown that it supports the hypothesis of Mitra (1943) in which the luminescent layer is identified with Region-F.

There were also nights in which the night sky intensity varied abnormally but the electron density of Region-F did not follow the same trend. These nights were found to be *free* from magnetic disturbance.

INTRODUCTION

Measurements of the intensity of the night sky light (both the total intensity and the intensities of the different spectral components) carried out in different parts of the world show that the intensity is variable. The variations, as measured by different observers, may conveniently be classified as follows:

1. Long period (eleven-year solar cycle) variation.—This shows strong positive correlation with the mean yearly sunspot area (Rayleigh and Jones, 1935; Smith, Gilliland and Kirby, 1938).

2. Seasonal variation.—This has maxima at equinoxes and minima at solstices (Martyn and Pulley, 1936).

3. Nightly variation.—This has a regular and an irregular part. The irregular variation shows strong correlation with magnetic activity (Barber, 1941) and, as such, its origin may be the same as that of aurora and magnetic storm, namely, bombardment of the upper atmosphere by charged particles emanated from the sun. In regard to the regular part, opinions of observers are unfortunately not the same as to its variation. In the Table given below, the available data on this point are summarised.

It will be noticed from the Table that there is considerable divergence regarding the nature of the variation as observed in different parts of the world. It was therefore thought that additional data might throw more light on the point and observations were made at Calcutta (lat. 22°33 N., long. 88° 21 E.) on selected nights during the years 1943-45 taking advantage of the black-out condition of the city. It should be mentioned that owing to unfavourable weather condition, observations could be carried out only for seven months in a year—October to April.

Another object of the investigation was to test Mitra's hypothesis of the night sky emission (Mitra, 1943 ; Ghosh, 1943). In this hypothesis, Region-F of the ionosphere has been identified with the luminescent layer of the night sky. The reaction which excites the night sky spectrum is one of electron transfer from negative ions of atomic oxygen to positive ions of nitrogen molecules, both of which are abundantly present in the Region-F at night. According to the theory, therefore, one would expect some sort of a correlation between nocturnal variation of electron density of Region-F and that of night sky intensity. In order to test if such correlation existed, simultaneous observa-

Observer	Place of observation	Observed region of spectrum	Nature of variation
Rayleigh (1929)	Terling, England	Wavelengths shorter than $\lambda 5577$	The intensity increases as night progresses ; attains a maximum near about local midnight and then begins to decrease again.
Cerniajev, Kvostikov and Panschin (1937)	Caucasus mountains	$\lambda\lambda 4550$ to 5900	,, ,,
Barber (1941)	Mt. Hamilton, Central California	Yellow green region	In addition to a maximum near about local midnight, there is some indication of a secondary maximum at about 3 A.M.
Bradbury and Sumerlin (1940)	,, ,,	Red and blue regions	For the blue radiation, the variation is same as that found by Rayleigh. For the red, there is a steady decrease throughout the night.
Karandikar (1934)	Poona, India	Red, green, blue and violet regions	The intensity decreases as night progresses, attains a minimum near about local midnight and then begins to rise again.
Elvey (1943)	McDonald Observatory, Texas, U. S. A.	Total intensity	The variations can be classified into two groups: (i) Same as that found by Karandikar. (ii) There is a slow and steady decrease in intensity throughout the night.

tions of night sky intensity and of the electron density were made on dark clear nights as were available, four days before and four days after the new moon of every month. Unfortunately, the electron density measurements could only be started from October, 1944. This was because the transmitting licence of the ionosphere apparatus with which the observations were being carried out under the auspices of the Radio Research Committee of the C. S. I. R. had been withdrawn due to war. This was restored from about that date.

With the cessation of the black-out condition in the city in May, 1945, the investigation had to be suspended due to interference of stray light.

EXPERIMENTAL ARRANGEMENT

The experimental equipment for the measurement of the night sky light is essentially that used by Fabry (1910) and is shown in Fig. 1. A telescope with

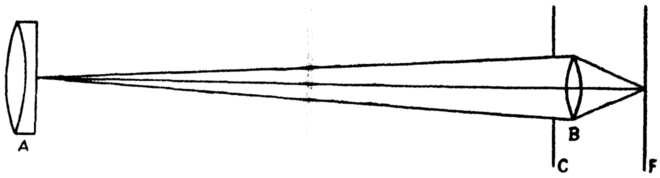

FIG. 1

Telescopic arrangement for intensity measurement of night sky light by photographic blackening. A—object glass, C—a circular opening in the focal plane of A. B forms an image of the exit pupil of the objective on the photographic film F.

objective A and eyepiece B is pointed towards the region of the sky to be studied. The objective is achromatic, 4″ in diameter and 57 cm. in focal length. In its focal plane a circular opening C is placed. The eyepiece placed behind the opening is a double convex lens of focal length 3 cm. A single lens is used as the eyepiece in order to reduce the absorption of light. The eyepiece throws on the photographic film F an image of the exit pupil of the objective. The telescope receives light from a solid angle of about 1.5×10^{-3} radian of the sky. It is clear that C being in the focal plane of the objective, the image on the photographic film will have uniform illumination. The film-holder could be moved up and down by a rack and pinion arrangement so that different parts of the film could be exposed when necessary.

Observations were made on dark clear nights at every hour, starting in majority of cases at 9 P.M. and ending before the morning twilight. The telescope was focussed 6° above the Pole Star. This region was chosen because of the absence of bright stars therein throughout the night. Photographic impressions were taken on H.P. 3 (Ilford) cut-film which gives sufficient blackening for an exposure of 3 minutes only. All the impressions of a single night were taken on one and the same film and were measured by a Moll microphotometer next day.

RESULTS OF OBSERVATIONS

Out of the total 50 nights observed, the variation on 35 nights followed a typical course. On such nights the intensity decreased with the advance of night, attained a minimum near about local midnight then again increased (Fig. 2). From data obtained from Alibag Observatory, it was found that these nights were free from magnetic activity. The trend of variation of

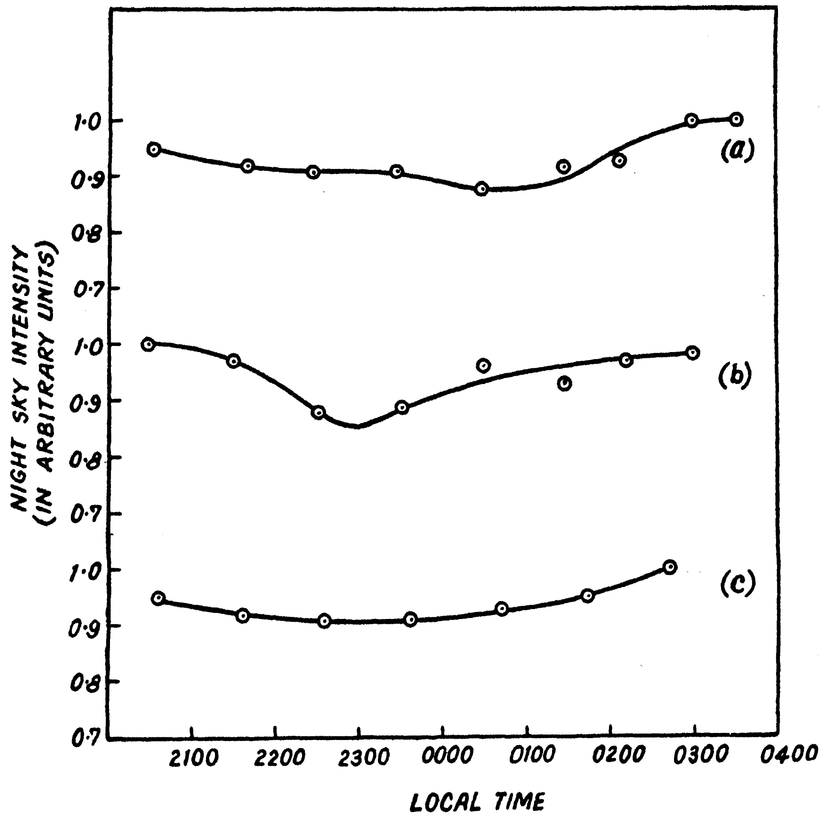

FIG. 2

Typical variation of the night sky intensity. (a) Feb. 23-24, 1944; (b) Feb. 26-27, 1944; (c) Oct. 17-18, 1944. The intensity decreases with the advance of the night, attains a minimum near about local midnight and then again increases. (The maximum intensity is taken as unity.)

night sky light at Calcutta is, therefore, same as that observed by Karandikar (1934) at Poona and Elvey (1943) at Texas. Elvey, however, found in addition nights in which there is a slow and steady decrease in intensity throughout the night. No such nights were found in our observations.

30 per cent of the observed nights were found to be disturbed, *i.e.*, the intensity variation was erratic. Not all of such nights were, however, associated with magnetic activity.

Simultaneous observations of Region-F electron density and of the night sky light showed that on undisturbed nights, on which, the night sky intensity showed a typical variation, f_F^2 (which is proportional to electron density) also did the same. The two variations, however, did not follow similar trend. While the typical variation of the night sky intensity was as described above, that of the Region-F electron density, was as follows: there was a decrease of electron density immediately after nightfall, the decrease continued up to the midnight when there was a tendency to rise. Afterwards the density fell gradually to about one-fourth of the evening value before sunrise. Fig. 3 shows typical variations of night sky intensity and the corres-

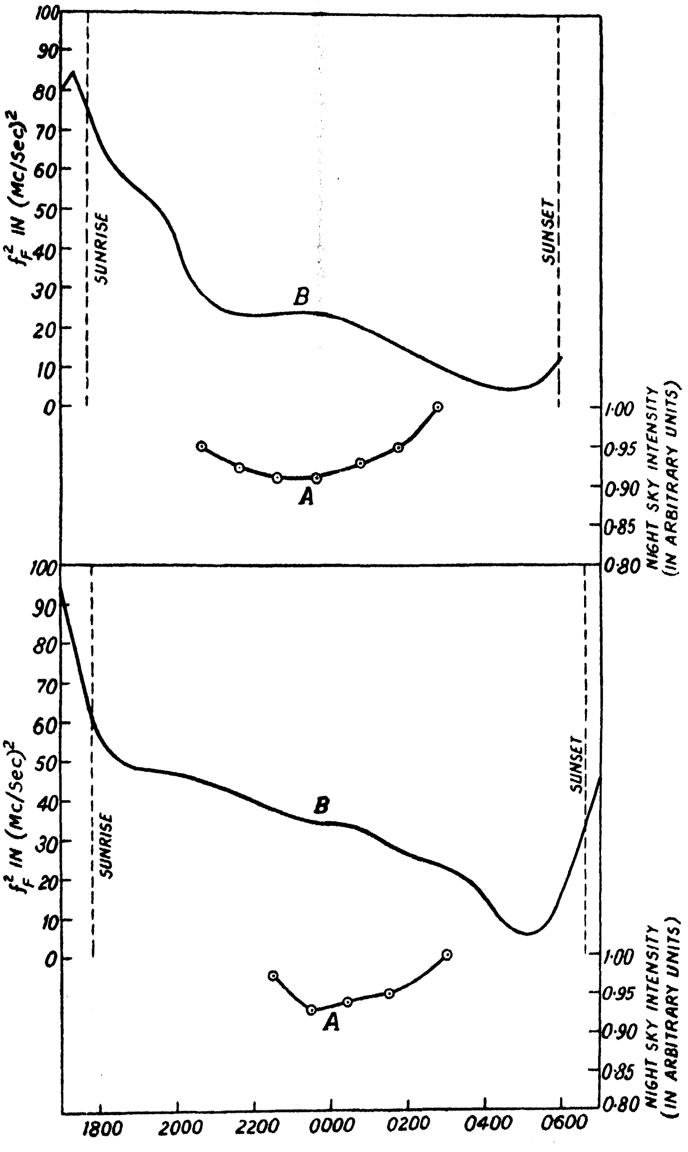

FIG. 3

Comparison of the variations of the night sky intensity (A) with the corresponding variation of f_F^2 (B) for two *normal* nights. Upper curves are for Oct. 5-6, 1944 and the lower for Oct. 17-18, 1944. Note that the variation of the night sky light intensity does not follow that of f_F^2.

ponding variation of f_F^2 for two normal nights. It is at once noticed that the two variations do not follow each other. That there may not be any correspondence between the two variations is also expected from Mitra's hypothesis.

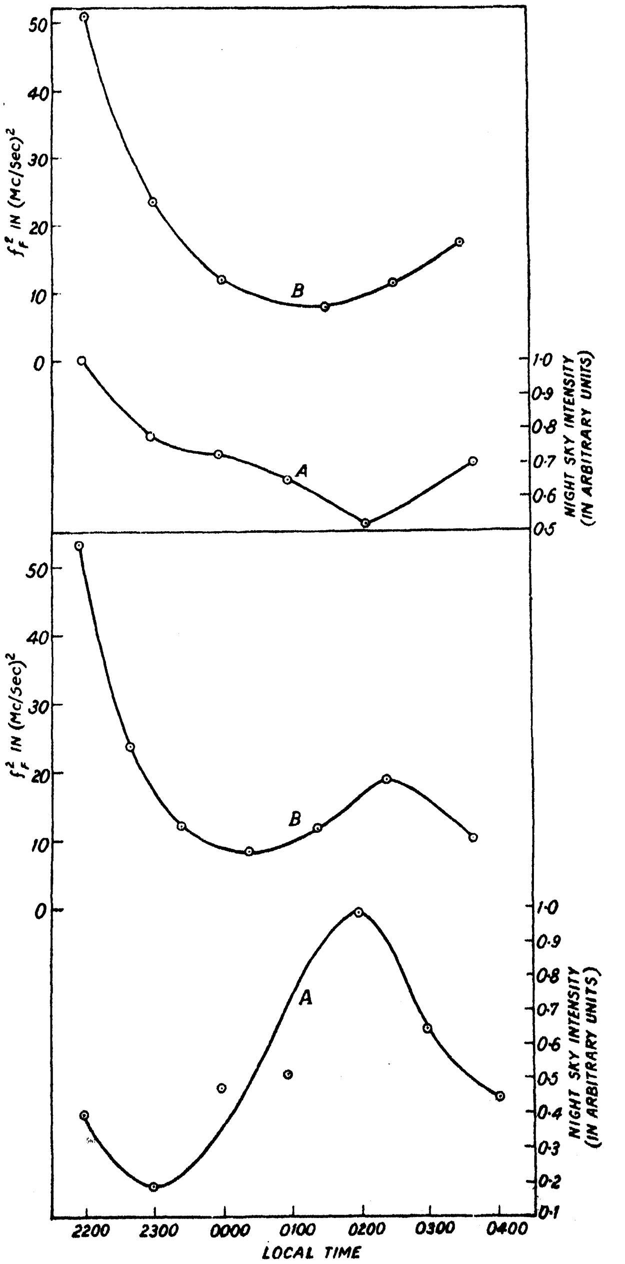

FIG. 4

Comparison of the variations of the night sky intensity (A) with that of f_F^2 (B) for two *abnormal* nights *with* magnetic disturbances. The upper curves are for Feb 14-15, 1945 and the lower curves for Feb. 15-16, 1945. It is to be noticed that the variation of the night sky intensity follows the same trend as that of f_F^2.

During the period of the investigation, there were two abnormal nights, namely, Feb. 14-15 and 15-16, 1945 on which there were magnetic disturbances. On these nights it was found that the variation of the intensity of the night sky light followed the same trend as that of $f_F{}^2$. In Fig. 4 the two variations are compared. It will be noticed that the two curves run approximately parallel to each other. A proof in support of Mitra's hypothesis is thus furnished.

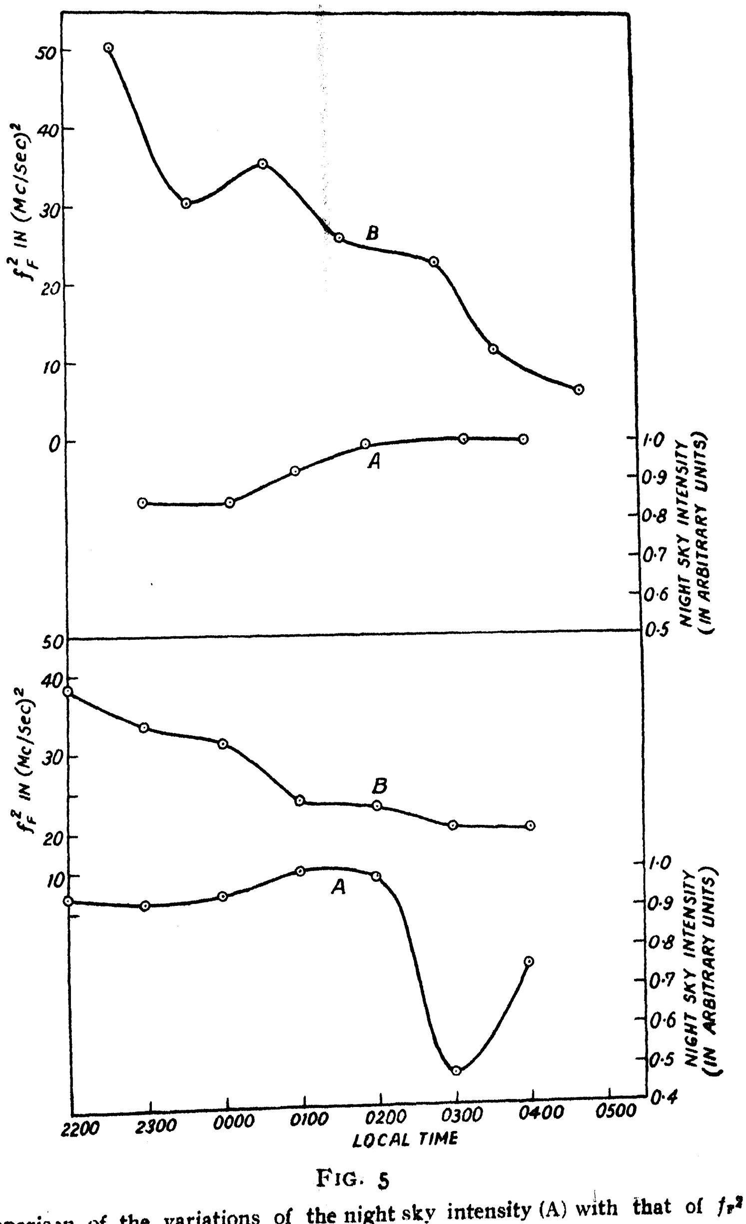

FIG. 5

Comparison of the variations of the night sky intensity (A) with that of $f_F{}^2$ (B) for two *abnormal* nights *free* from magnetic disturbances. Upper curves are for April, 16-17, 1945 and the lower curves for January 18-19, 1945. Note that the variution of $f_F{}^2$ does not follow that of the night sky intensity.

There are also nights in which, though the night sky light varied abnormally, the variation of $f_F{}^2$ did not follow that of the night sky intensity. These nights were found to be *free* from magnetic activity. In Fig. 5 the variations of night sky intensity for two such nights are compared with those of $f_F{}^2$. It will be seen that there is hardly any similarity between the two.

DISCUSSION

It appears that on undisturbed nights, the variation of the night sky intensity in sub-tropical latitudes like those of India follows a trend similar to that at Texas (lat. 31°30 N).

On disturbed nights which are accompanied by magnetic disturbance, the trend of variation is approximately the same as the variation of maximum ionisation of Region-F. This correlation is discussed below and supports the hypothesis of Mitra that the luminescent layer is to be identified with Region-F.

The variations of electron density, as obtained from ionospheric measurements, are those occurring in the region of maximum ionisation. These variations do not tell anything about the nature of variation of the total number of electrons present in a column of unit cross-section of Region-F. But the intensity of the night sky emission depends precisely on this latter quantity. The electron density, for instance, may increase due to contraction by cooling of the ionised region as a whole, but the total number of electrons in a column of unit cross-section may remain more or less constant.

A positive correlation between the variation of the night sky intensity and the variation of the Region-F maximum density would, therefore, be expected only when the latter variation follows a trend similar to the variation of the electron content of the region as a whole. This is the case with abnormal nights associated with the magnetic activity when the electron content of the region as a whole (not merely the maximum electron density) may be expected to be affected.

Correlation between the variation of the night sky intensity and of the maximum electron density of Region-F may not, therefore, always be expected. It occurs only on nights of abnormal activity with magnetic disturbance.

For similar reason, the long-period variations of night sky intensity and maximum electron density of Region-F should vary concurrently. Several workers (Rayleigh and Jones, 1935, Smith, Gilliland and Kirby, 1938 and Martyn and Pulley, 1936) have, in fact, found unmistakable correlation between the seasonal and eleven-year solar cycle variations of night sky intensity with those of the maximum electron density of Region-F.

It is very significant that no correlation whatsoever has been observed between the Region-E electron density variation and the night sky intensity variation (Bradbury and Sumerlin, 1940). This is what is expected if the night sky luminescence is to originate from Region-F.

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REFERENCES

Barber, D. R., 1941, *Lick. Obs. Bull*, **19**, 105.

Bradbury, N. E. and Sumerlin, W. T., 1940, *Terr. Mag. and Atmos. Elec.*, **45**, 19.

Cerniajev, Kvostikov and Panschin, 1937, *J. de Phys.*, **7**, 149.

Elvey, C. T., 1943, *Astrophys. J.*, **97**, 65.

Fabry, C., 1910, *Comptes Rendus*, **150**, 272.

Ghosh, S. N., 1943, *Proc. Nat. Inst. Sci. (India)*, **9**, 301.

Karandikar, J. V., 1934, *Ind. J. Phys.*, **8**, 547.

Martyn, D. F. and Pulley, O. O., 1936, *Proc. Roy. Soc. A*, **154**, 455.

Mitra, S. K., 1943, *Science and Culture*, **9**, 46

Rayleigh, Lord, 1929, *Proc. Roy. Soc. A*, **124**, 395.

Rayleigh, Lord, and Jones, H. S., 1935, *Proc. Roy. Soc. A*, **151**, 22.

Smith, N., Gilliland, T. R. and Kirby, S. S., 1938, *J. Nat. Bur. Stand.*, **21**, 835.